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RESEARCH MEMORANDUM

for the

Ordnance Department, Department of the Army

TESTS OF A HERMES A-2 MISSILE BODY AT MACH NUMBER 4.04

By Edward F. Ulmann and Douglas R. Lord

Langley Aeronautical Laboratory
Langley Air Force Base, Va.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON

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SUMMARY

Force tests on a proposed body shape of the Hermes A-2 missile with and without longitudinal spoilers were made at Mach number 4.04. Values of normal-force coefficient, pitching-moment coefficient, and center-of-pressure position were obtained.

INTRODUCTION

In accordance with a request from the General Electric Company's Hermes Project, tests at Mach number 4.04 of a possible body shape of the Hermes A-2 guided missile were undertaken. Approval for the tests was given on July 5, 1950 in telephone conversations involving Mr. R. H. Norris of the General Electric Company and Messrs. I. H. Abbott and J. Stack of the National Advisory Committee for Aeronautics. The test program was drawn up on July 7, 1950 by Mr. V. B. Corbo of the General Electric Company and members of the Compressibility Research Division of the Langley Laboratory.

The purpose of the tests was to determine the values of the normal-force coefficients, the pitching-moment coefficients, and the center-of-pressure positions on the body at angles of attack up to 30° at Mach number 4.04. Force tests using an internally mounted strain-gage balance were conducted in the Langley 9- by 9-inch Mach number 4 blow-down tunnel, and the data are presented herein without analysis in order that they be made available as quickly as possible.

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SYMBOLS

p	stream static pressure
M	stream Mach number
γ	ratio of specific heats of air (1.4)
q	dynamic pressure $\left(\frac{\gamma}{2} pM^2\right)$
l	body length
d	body diameter
s	projected frontal area of body
N	body normal force
M	body pitching moment measured about the 33.65-percent-body-length point
C_N	body normal-force coefficient $\left(\frac{N}{qs}\right)$
C_M	body pitching-moment coefficient $\left(\frac{M}{qsd}\right)$
α	angle of attack
x_{cp}	distance of center of pressure from the nose of the body in percent body length
R	Reynolds number based on body length

APPARATUS AND TESTS

The tests were conducted in the Langley Mach number 4 blowdown tunnel which has a test section 9 inches square. In this tunnel a pressure-regulating valve holds the settling-chamber pressure at values between 150 and 250 pounds per square inch absolute. This pressure and the corresponding air temperature are continuously recorded on film during each run. For the subject tests the absolute humidity of the air used was 0.000009 or less.

Schlieren photographs of the flow around the models were obtained by use of a system incorporating a spark discharge of 1 microsecond duration. The normal forces and pitching moments on the models were measured by a strain-gage sting balance located inside the model. The center of moments of the balance was 33.65 percent body length downstream of the model nose. The balance was temperature-compensated, although no large temperature effect was anticipated because of the short duration (15 to 20 sec.) of the test runs. Readings of normal force and pitching moment were made visually simultaneously with schlieren photographs and recordings of stagnation pressure and temperature.

The basic model was 9 inches long and had a fineness ratio of 9. It was tested in a completely smooth condition and with two sizes of longitudinal spoilers located in the plane perpendicular to the angle-of-attack plane. These spoilers had maximum spanwise projections of 0.011 inch and 0.044 inch (see figs. 1 and 2). The sting which incorporated the strain-gage balance was 5/8 inch in diameter and extended 5 inches beyond the base of the model. Two inches of the sting fitted into the socket of the support strut (see fig. 3). Angle-of-attack changes were made by rotating the model about a point located at the one-half-body-length position. Tests were made at angles of attack of approximately 0°, 5°, 10°, 15°, 20°, and 30°. The actual angles of attack under running conditions were measured from the schlieren negatives by use of an optical comparator. The test Reynolds number, based on body length, was 19×10^6.

The accuracy of the data as indicated by repeat test runs is ±0.02 in normal-force coefficient, ±0.04 in pitching-moment coefficient, and ±1.00 percent of body length in center-of-pressure position. These coefficient inaccuracies are less than ±1.00 percent of the full-scale readings.

RESULTS AND DISCUSSION

The results of the force measurements are presented as the variation of normal-force coefficient, pitching-moment coefficient, and center-of-pressure position with angle of attack at a Mach number of 4.04 (figs. 4, 5, and 6). The results are also presented in tabular form in table I. The data generally indicate that the effect of the spoilers was small. The normal-force coefficients for the model with the large spoilers were only slightly higher than those obtained for the smooth model throughout the angle-of-attack range (fig. 4). The effect of the spoilers on the pitching-moment coefficient and the center-of-pressure position was negligible.

The schlieren photographs of the smooth model obtained simultaneously with the force measurements are presented in figure 7. These photographs are representative of the flow past all the models, since no effect of the spoilers could be determined, as is illustrated in figure 8 by a comparison of schlieren photographs of the flow past the smooth model and the large-spoiler model at 20° angle of attack.

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TABLE I.- TEST RESULTS FOR THREE PROPOSED HERMES A-2 MISSILE BODIES AT MACH NUMBER 4.04 AND REYNOLDS NUMBER 19×10^6

Smooth model				Small-spoiler model				Large-spoiler model			
α	C_N	C_M	x_{cp}	α	C_N	C_M	x_{cp}	α	C_N	C_M	x_{cp}
-0°10'	-0.009	0.028	----	-0°10'	-0.015	0.028	----	-0°10'	-0.017	0.019	----
5°6'	.346	.093	36.7	5°6'	.360	.074	36.8	5°6'	.355	.102	36.9
9°41'	.865	.853	44.6	------	------	-----	----	9°53'	.917	.933	45.0
11°9'	1.028	1.097	45.7	11°13'	1.041	1.068	44.8	------	------	-----	----
15°4'	1.592	1.918	47.1	15°4'	1.610	1.889	46.7	15°4'	1.666	1.982	46.9
20°6'	2.330	3.213	49.0	20°6'	2.366	3.203	48.7	20°6'	2.429	3.277	48.7
30°9'	4.295	6.763	51.2	30°9'	4.330	6.722	51.0	30°9	4.382	6.829	51.0

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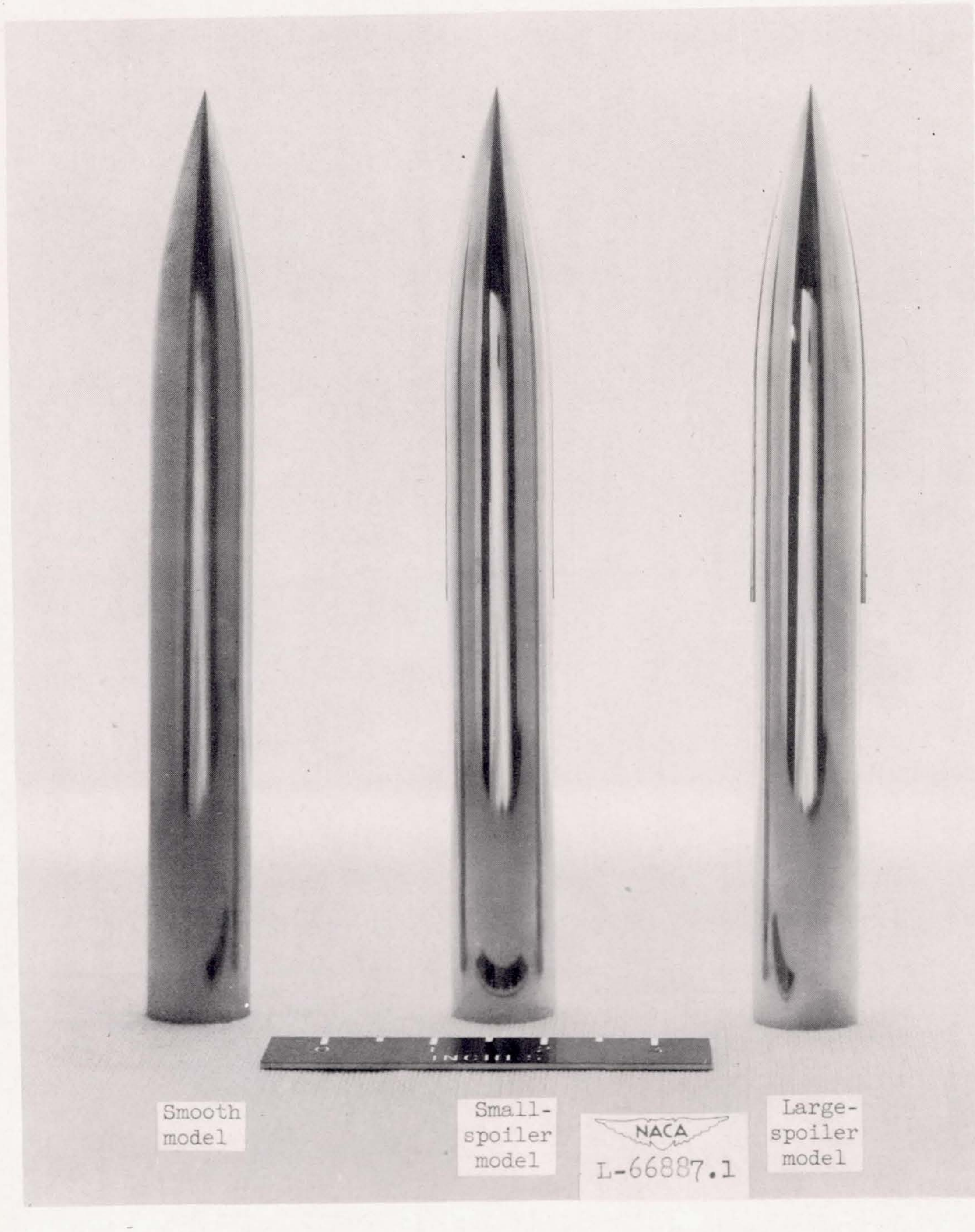

Figure 1.- Models of Hermes A-2 missile body.

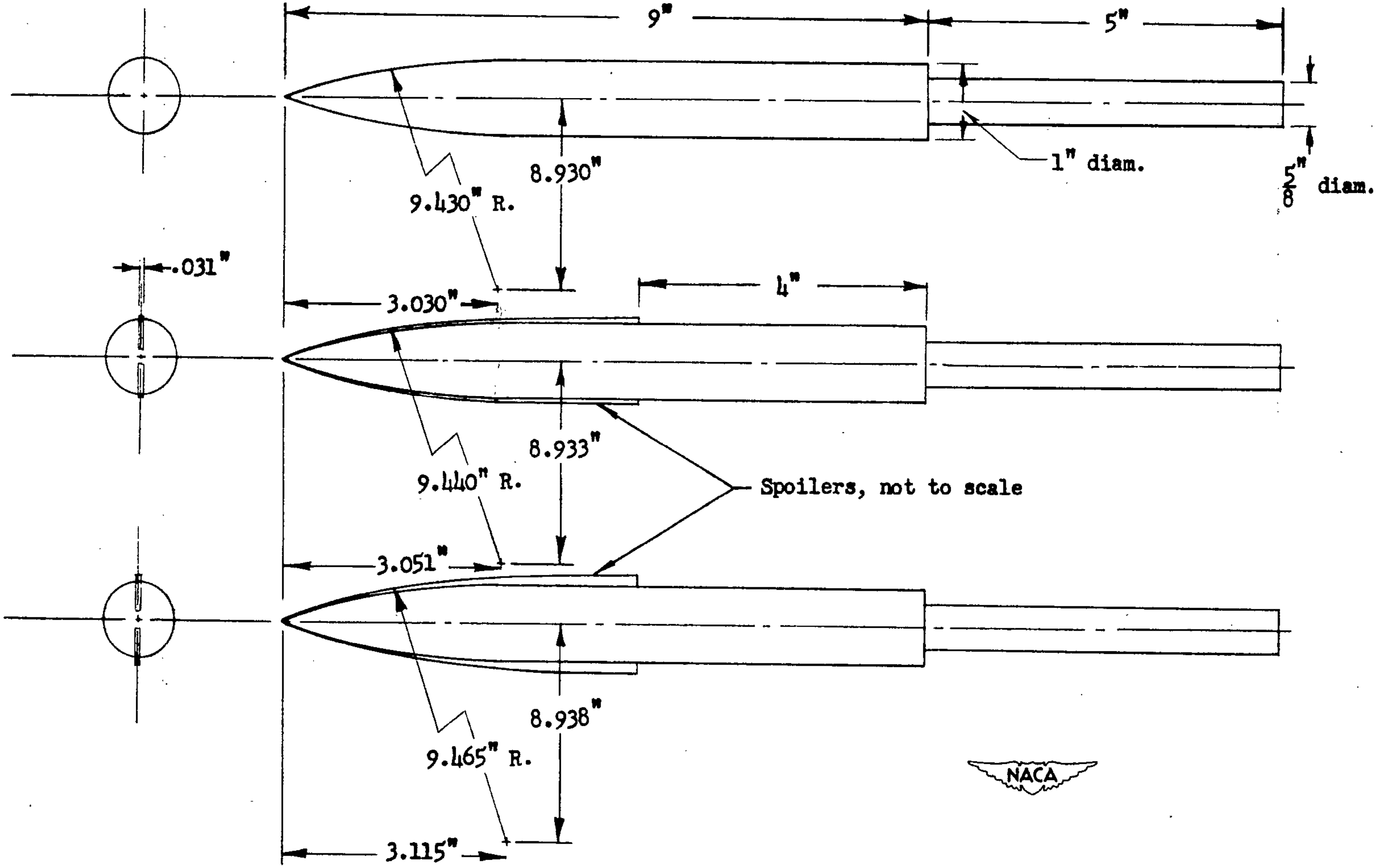

Figure 2.- Dimensions of three proposed models of the Hermes A-2 missile body.

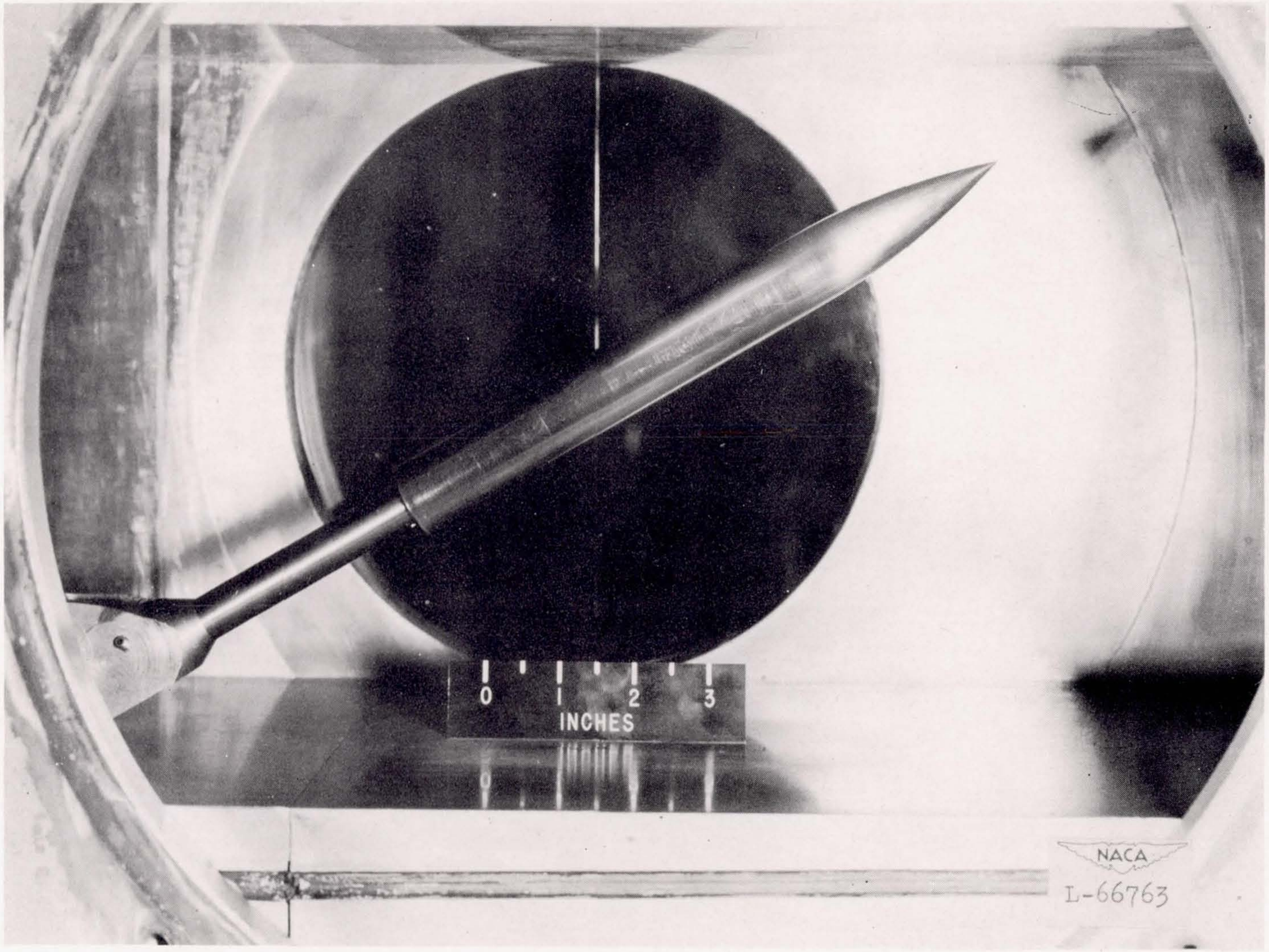

Figure 3.- Test section of Langley 9- by 9-inch Mach number 4 blowdown tunnel with Hermes A-2 model mounted on the sting.

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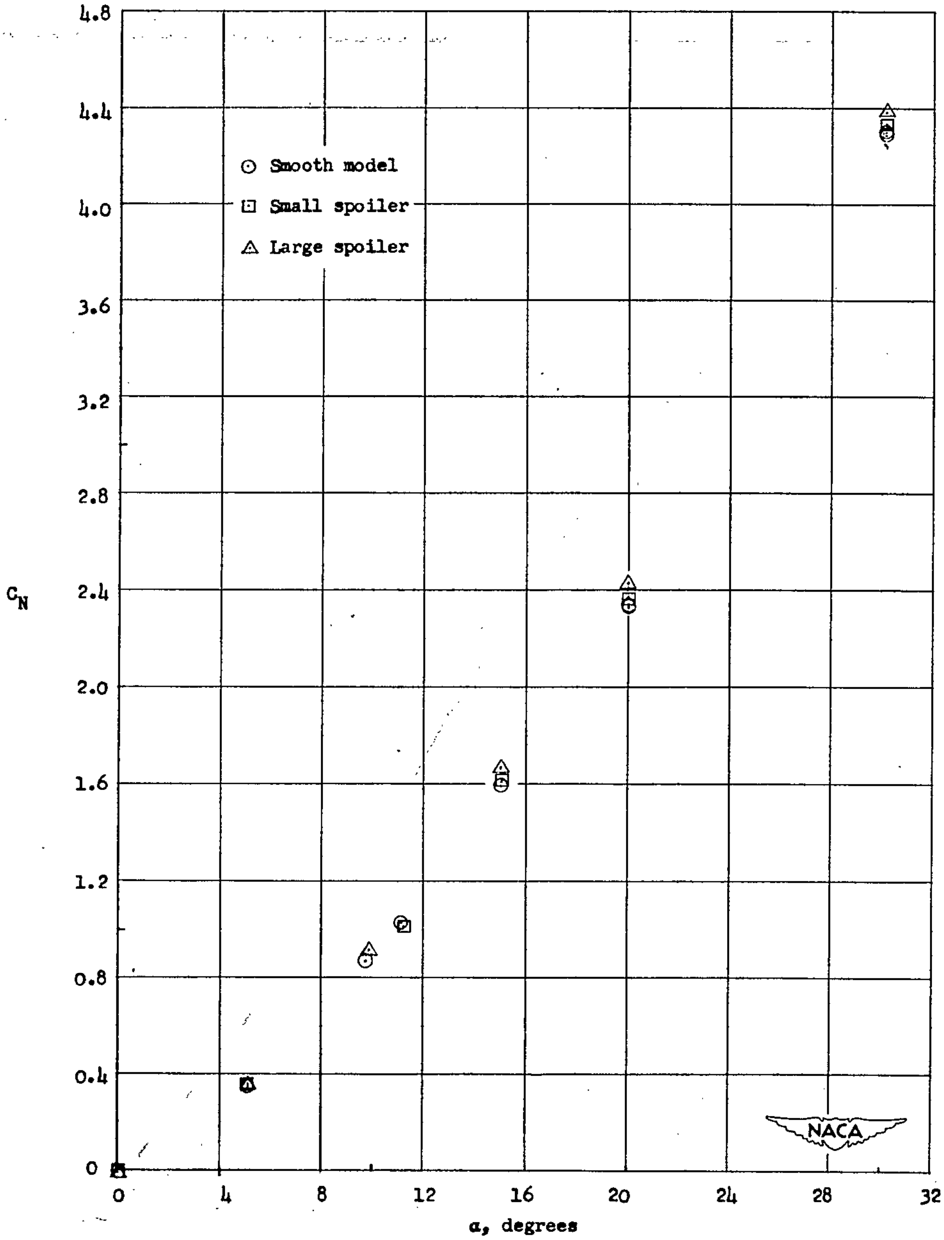


Figure 4.- Variation of body normal-force coefficient with angle of attack for a proposed Hermes A-2 missile body with and without longitudinal spoilers. $M = 4.04$; $R = 19 \times 10^6$.

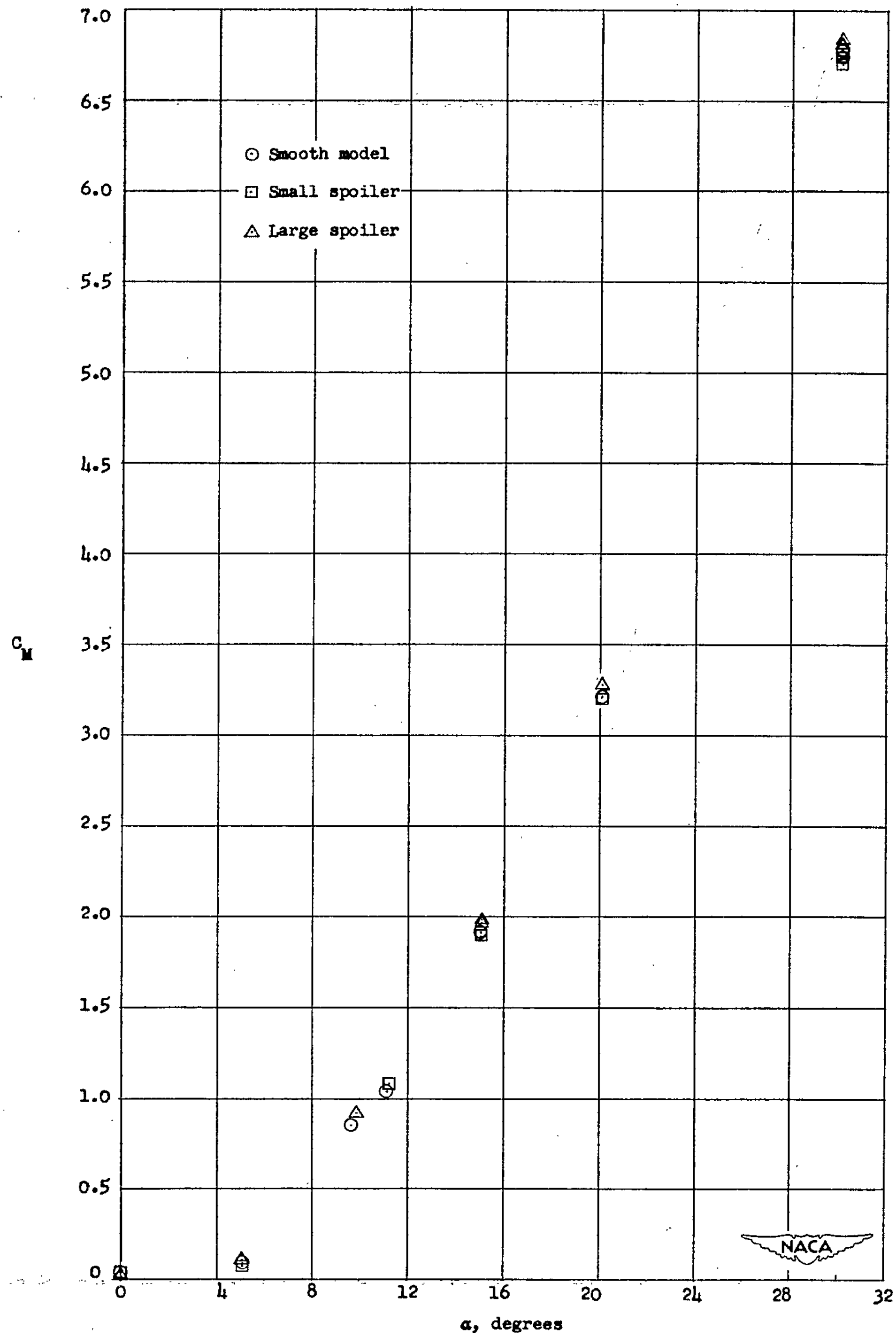


Figure 5.- Variation of body pitching-moment coefficient with angle of attack for a proposed Hermes A-2 missile body with and without longitudinal spoilers. $M = 4.04$; $R = 19 \times 10^6$.

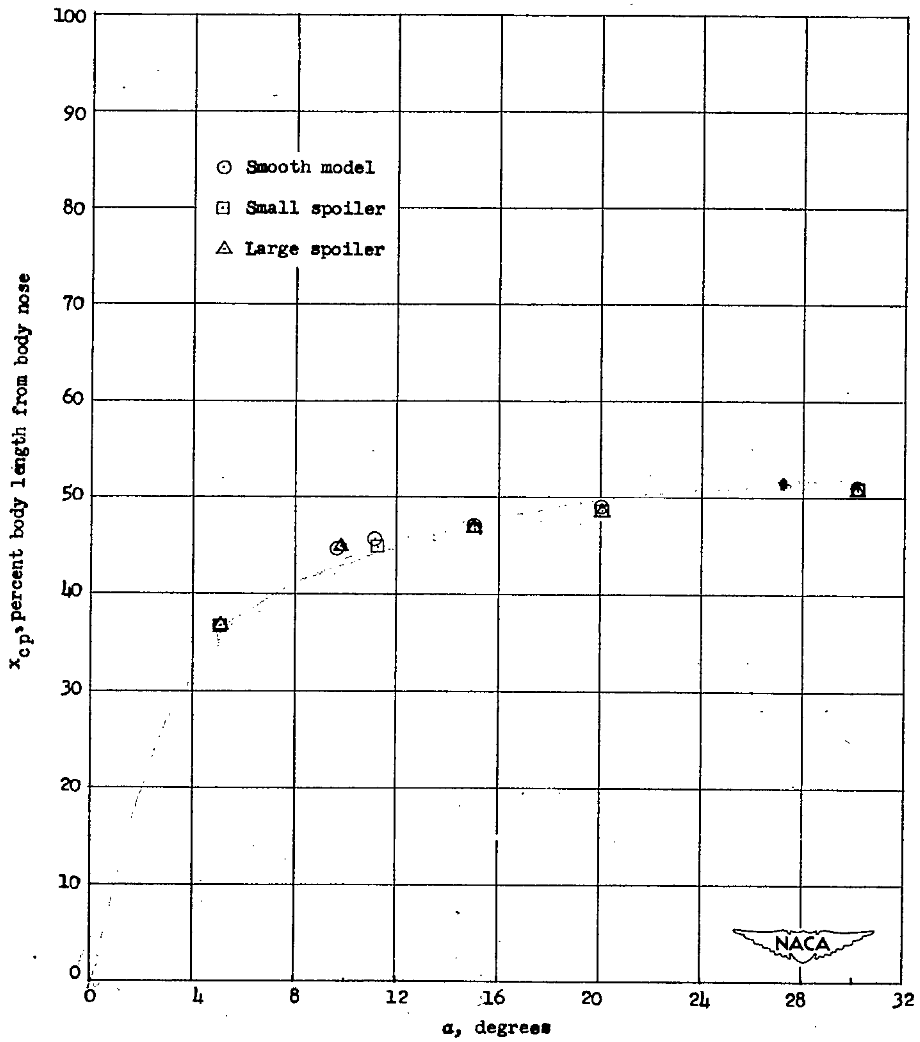
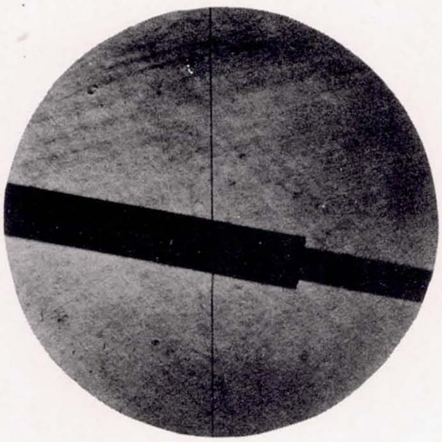
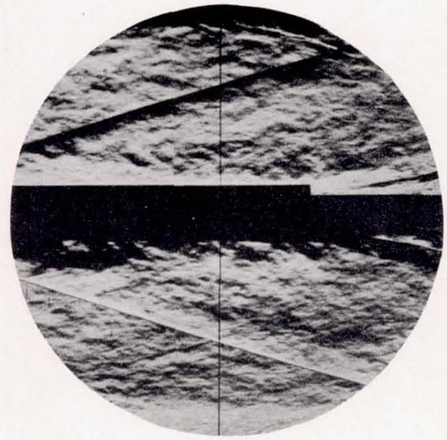


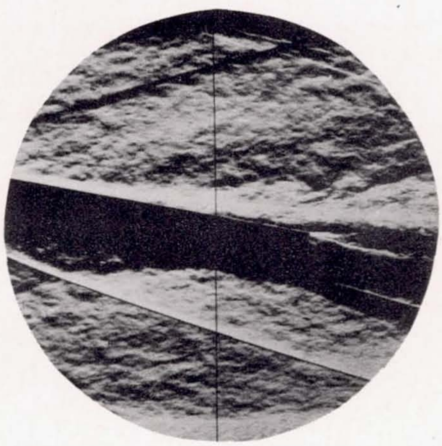
Figure 6.- Movement of the center of pressure with angle of attack for a proposed Hermes A-2 missile body with and without longitudinal spoilers. $M = 4.04$; $R = 19 \times 10^6$.



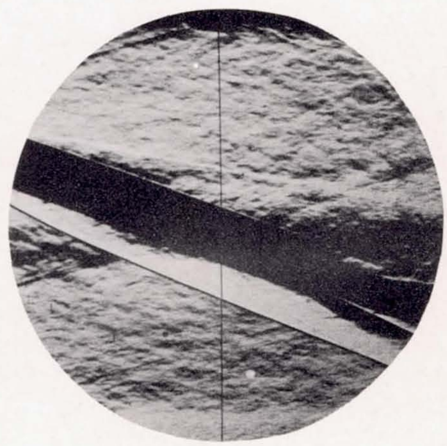
No flow condition



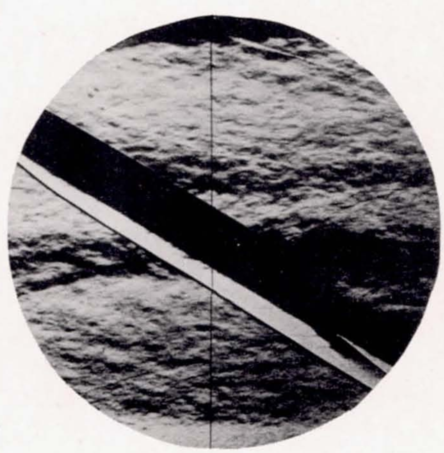
$\alpha = -0^{\circ}10'$



$\alpha = 11^{\circ}9'$



$\alpha = 20^{\circ}6'$



$\alpha = 30^{\circ}9'$

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Figure 7.- Schlieren photographs of the rear portion of a proposed Hermes A-2 missile body. Smooth model; $M = 4.04$; $R = 19 \times 10^{6}$. Knife edge horizontal.

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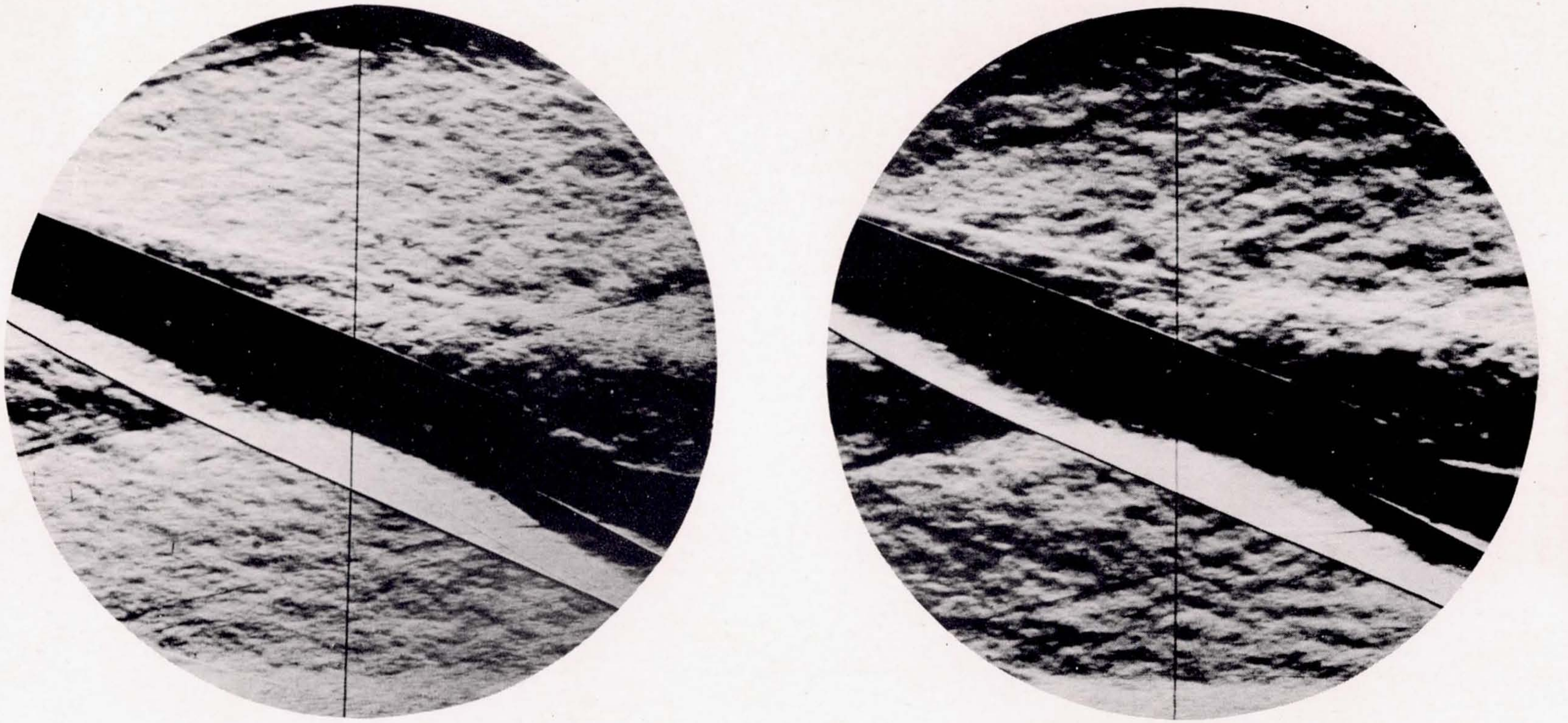

(a) Smooth model.

$\alpha = 20^{\circ}6'$.

(b) Large spoiler model.

$\alpha = 20^{\circ}6'$.

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Figure 8.- Schlieren photographs of the rear portion of a proposed Hermes A-2 missile body. $M = 4.04$; $R = 19 \times 10^{6}$. Knife edge horizontal.

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